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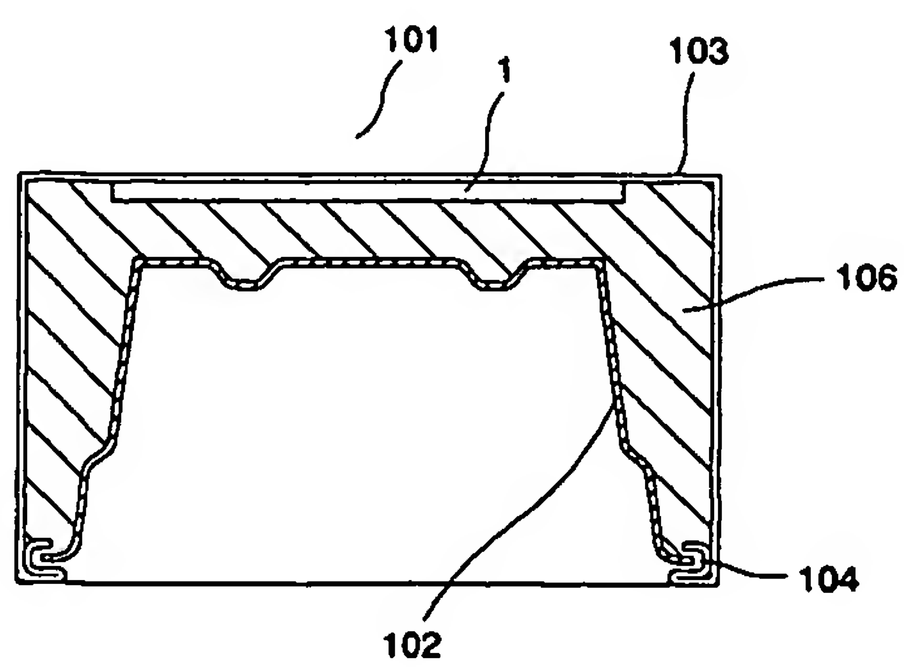
(54) HEAT INSULATION BOX, AND VACUUM HEAT INSULATION MATERIAL USED THEREFOR

(57) By using vacuum heat insulator comprising a core made of laminated sheets of an inorganic fiber having a particular shape and composition as a vacuum heat insulator for a heat insulation box, a heat insulation box excellent in long-term heat insulating property and productivity can be provided. The vacuum heat insulator can be shaped easily. Therefore, a vacuum heat insulator suitable for a required heat insulation portion can be produced easily and applied to a heat insulation box. This property can increase coverage of the vacuum heat insulator on the heat insulation box, thus improving the heat insulating property of the heat insulation box. This can improve the heat insulating property and productivity of a refrigerator, thermal storage box, cold storage box, or vending machine, and contribute to an energy saving.

FIG. 7



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heat insulation box that can be used for apparatus, such as a refrigerator, thermal storage box, cold storage box, vending machine, a water heater. It also relates to a vacuum heat insulator used for these apparatus and to the heat insulating structure of the heat insulator.

BACKGROUND OF THE INVENTION

[0002] Energy saving in electric appliances is an unavoidable important problem to address in recent years. Also in a heat insulation box used for a refrigerator and other various kinds of electric appliances, improvement in the performance of the heat insulator is becoming essential. On the other hand, positive efforts to conserve terrestrial environment is becoming important. One of urgent requests to electric appliances is energy saving: thus, improving heat insulating property of heat-related electric apparatus is becoming an important problem to address.

[0003] One of heat insulators that have recently been developing mainly by manufacturers of electric appliances and heat insulators for energy and space saving is a vacuum heat insulator that has excellent heat insulating property. An example of the vacuum heat insulator is made by covering a core made of a rigid urethane foam having continuous pore with a gas-barrier laminated film and evacuating the inside thereof. This vacuum heat insulator has heat insulating property approximately 2.5 times the heat insulating property of conventional rigid or soft urethane foam or resin foam.

[0004] Japanese Patent Examined Publication No. H05-63715 discloses a vacuum heat insulator using a fibrous aggregate. A use of the fibrous aggregate of glass fibers, ceramic fibers, or resin fibers as a core of a vacuum heat insulator provides a light and deformable vacuum heat insulator.

[0005] Moreover, according to Japanese Patent Examined Publication No. 30-3139, a vacuum heat insulator made of a core of glass fibers each having a diameter of 250 μm or smaller is proposed. Inside of the vacuum heat insulator is maintained to a degree of vacuum of 0.75 Pa or lower. Japanese Patent Laid-Open Publication No. 60-208226 discloses randomly laminated inorganic fibers having a small diameter in a direction perpendicular to a heat transfer direction, and another fibers are sewn perpendicularly to the laminated inorganic fibers halfway to form a core of a vacuum heat insulator.

[0006] An example of binding fibers using a binder is disclosed in the Japanese Patent Laid-Open Publication No. H-138058. In this invention, a fiber material such as glass wool is molded using an organic binder, and used as a core of a vacuum heat insulator.

[0007] However, these conventional techniques have following problems and thus are difficult to be put to practical use.

[0008] For example, the vacuum heat insulator disclosed in Japanese Patent Examined Publication No. 30-3139 is difficult to be formed into a specific shape because it is made of glass fibers only. When a sheet-form vacuum heat insulator is to be produced, using the fibers as a core of the vacuum heat insulator requires much manpower because the fibers themselves do not have shape-keeping property.

[0009] Since the inorganic fibers are sewn with other fibers in Japanese Patent Laid-Open Publication No. 60-208226, the shape-keeping property is imparted to the fibers themselves and the problem of the shape-keeping property is solved. However, as general methods cannot be used to sew the fibers, while reducing the heat conduction, the process has a problem of high production cost.

[0010] Japanese Patent Laid-Open Publication No. H-138058 proposes binding fibers using an organic binder as a method of imparting the shape-keeping property to fiber material. However, the publication only discloses the type of the binder and does not disclose an amount of the binder or a composition of the fiber. Thus, there is a problem that it is difficult to bind fibers using the binder while maintaining the heat insulating property suitable for a vacuum heat insulator. In addition, when organic fibers are used for a core, the core generates gases during a long-term usage, thus, the heat insulating property may be degraded.

[0011] In order to improve a heat insulating property of a heat insulation box, a heat insulation box that uses a heat insulator using a resin foam or powder as the core has been proposed. Such a core has a problem of long-term heat insulating property or workability. As described above, the conventional techniques have the problems such as a poor workability of the vacuum heat insulator, or a premature stage of product development, and the advantages of fiber aggregates are not utilized sufficiently.

[0012] In consideration of the above problems, the present invention aims to provide a heat insulation box excellent in heat insulating property and in productivity by using a core made of laminated sheets of an inorganic fiber, the core of the heat insulator is excellent in long-term reliability and in workability.

DISCLOSURE OF THE INVENTION

[0013] In order to address the above problems, a heat insulation box of the present invention uses, as a heat insulator, a vacuum heat insulator that includes a core made of laminated sheets of an inorganic fiber, and a laminated film sandwiching the core. Further, a laminated film disposed on one side of the laminated sheets and a laminated film disposed on another side of the laminate sheets have different lamination structures. Moreover, the vacuum heat insulator includes an ad-

sorbent as required.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a sectional view of a vacuum heat insulator of the present invention.
Fig. 2 shows a cut-off portion provided along a side of an inorganic fiber sheet of a core of a vacuum heat insulator of the present invention.
Fig. 3 shows a cut-off portion provided in a part of an inorganic fiber sheet of an uppermost layer.
Fig. 4 shows a cut-off portion provided in a part of an inorganic fiber sheet of an intermediate layer.
Fig. 5 shows cut-off portions provided in parts of all inorganic fiber sheets.
Fig. 6 is a perspective view of a refrigerator in accordance with a second exemplary embodiment of the present invention.
Fig. 7 is a schematic view of a heat insulation box in accordance with a third exemplary embodiment of the present invention.
Fig. 8 is a schematic view of the heat insulation box in accordance with the third exemplary embodiment of the present invention.
Fig. 9 is a schematic view of a heat insulation box in accordance with a fourth exemplary embodiment of the present invention.
Fig. 10 is a schematic view of a heat insulation box in accordance with the fourth exemplary embodiment of the present invention.
Fig. 11 is a schematic view of a lid in accordance with the fourth exemplary embodiment of the present invention.
Fig. 12 is a sectional view of a heat insulation box in accordance with a fifth exemplary embodiment of the present invention.
Fig. 13 is a sectional view of a refrigerator in accordance with a sixth exemplary embodiment of the present invention.
Fig. 14 is a sectional view of an insulation box in accordance with a seventh exemplary embodiment of the present invention.
Fig. 15 is a sectional view of a water heater in accordance with an eighth exemplary embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] Exemplary embodiments of the present invention are described hereinafter using specific examples.

First Embodiment

[0016] Fig. 1 is a sectional view of a vacuum heat insulator in accordance with an exemplary embodiment of the present invention. Vacuum heat insulator 1 comprises core 2, enveloping member 3, and adsorbent 4.

[0017] One side of the enveloping member 3 is made of a four-layer laminated film. The outermost layer of the laminated film is a polyamide layer (16 μm) as a surface protection layer and the inner layer thereof is a polyethylene terephthalate layer (12 μm). Enveloping member 3 further has an aluminum foil (6 μm) as an intermediate layer and a high-density polyethylene layer (50 μm) for heat-sealing.

[0018] Another side of the enveloping member 3 is made of a four-layer laminated film comprising surface protection layers of a polyamide layer (16 μm) and a polyethylene terephthalate layer (12 μm), an intermediate film layer made of an ethylene-vinyl alcohol copolymer resin composite film (15 μm) having a vacuum deposited aluminum on an inner side thereof, and a heat seal layer made of a high-density polyethylene layer (50 μm).

[0019] In the vacuum heat insulator 1 of the present invention, a laminated film of an aluminum foil is used for one side of the enveloping member 3 and another side thereof is made of a laminated film having the vacuum deposited aluminum. Thus, heat conduction is adjusted according to a temperature of the subject the vacuum heat insulator contacts. As a result, the heat insulator in its entirety can inhibit heat leak caused by the highly heat conductive aluminum foil, and an amount of gases entering into the heat insulator can be suppressed because of an existence of the deposited metal film excellent in gas barrier property.

[0020] In other words, because the aluminum foil is a metal film, it permits no gas entry even at an elevated ambient temperatures. However, the resin layer having vacuum deposited aluminum has permeability to gases with temperature increase. The gas-permeability decreases the degree of vacuum in the vacuum heat insulator, thus deteriorating the heat insulating property. To avoid the degradation, it is effective to place the aluminum foil side of enveloping member 3 of the vacuum heat insulator on a side exposed to higher temperatures. Thus, the structure of the vacuum heat insulator of the present invention can suppress degradation of the performance caused by the heat leak and the gas entry at the same time.

[0021] However, the structure of the vacuum heat insulator of the present invention needs not to be limited to the above structure. On the assumption of cost reduction of the enveloping member and use of the heat insulator at high temperatures, crystalline polypropylene (50 μm) can be used as the heat seal layer in the above structure of enveloping member 3, for example. This structure can improve heat-resistant temperature of the vacuum heat insulator.

[0022] Alternatively, eliminating the polyamide layer of the outermost layer and slightly thickening the polyethylene terephthalate layer can reduce the cost due to the elimination of the polyamide layer. In this case, degradation of bending resistance resulting from the elimination of the polyamide can be solved by a thickening

of the polyethylene terephthalate layer.

[0023] Moreover, depending on circumstances where the heat insulator is used, materials and structures of the enveloping member 3 should be selected. When the heat insulator is used at a relatively low temperatures, such as in a refrigerator or cooler box, high-density polyethylene or the like is suitable as a material for the heat seal layer. When the heat insulator is used at a relatively high temperatures, such as in a water heater, the crystalline polypropylene, the ethylene vinyl alcohol copolymer resin, the polyethylene terephthalate resin or a polyethylene naphthalate resin are suitable.

[0024] Alternatively, the enveloping member can be made of one kind of laminated film without differentiating a front and a back sides of the heat insulator. In this case, the sealing types of the enveloping member 3 are not limited to a three-side seal. So-called "gusset bag" or "pillow bag" can be used. The use of these bags can reduce a number of protrusions along outer periphery of enveloping member 3 resulting from the heat-sealing and further reduce a number of steps of folding the protrusions.

[0025] Adsorbent 4 is placed in a cut-off portion provided in a part of laminated core 2 except the uppermost and lowermost sheets. This placement can address the problem that the protruded adsorbent 4 may break enveloping member 3 in the production of the vacuum heat insulator.

[0026] As a material of adsorbent 4, the COMBO GETTER supplied by SEAS Getters is excellent, which can absorb and remove moisture and carbon dioxide as well as oxygen and nitrogen. Therefore, degradation of degree of vacuum of the vacuum heat insulator 1 can be inhibited for a long period of time. Other examples of the usable material include moisture adsorbent, such as calcium oxide and calcium chloride, and AGELESS (a registered trademark of Mitsubishi Gas Chemical Co., Inc). As a carbon dioxide adsorbent, any materials comprising calcium hydroxide can be used. When these inorganic compounds are further combined with the above COMBO GETTER of the SEAS Getters, the effect as adsorbent is improved and the property of vacuum heat insulator 1 can be maintained for a long period of time.

[0027] Core 2 is laminated with four sheets of inorganic fiber 2a. Cut-off portion 2b is provided along a side of inorganic fiber 2a. Adsorbent 4 is disposed in the cut-off portion 2b. This structure prevents adsorbent 4 from forming a protrusion on the surface of the heat insulator. This structure makes the fluid resistance of the gases on the surface of the sheet different from that between the plurality of laminated sheets at a time of evacuation of the heat insulator. As a result, vortex flow occurs in a air flow of sucked air, and the vortex flow improves evacuation efficiency, thus remarkably improving the productivity.

[0028] As another example of core 2, as shown in Fig. 3, recess 2b can be formed in the first layer of the inorganic fiber 2a to house the adsorbent 4. Alternatively, as shown in Fig. 4, through hole 2d can be formed through an intermediate layer of inorganic fiber 2a to house the adsorbent 4. Alternatively, as shown in Fig. 5, through holes 2e can be formed through all the layers of the inorganic fiber 2a to house the adsorbent 4.

[0029] The number of sheets 2a to be laminated is not specifically limited. However, in order to prevent adsorbent 4 from forming a protrusion, at least three sheets are preferable. In consideration of improvement in productivity, at least four sheets are more preferable.

[0030] In the present embodiment, the core 2 containing 50 to 65 wt. % of SiO_2, 10 to 20 wt. % of Al_2O_3 and CaO each, and 1 to 4 wt. % of MgO, is used as the composition of the material.

[0031] SiO_2 is used as a major constituent because the material has a low heat conductivity and low cost. The content of SiO_2 suitable for the vacuum heat insulator 1 preferably ranges from 50 to 65 wt.% in the composition of the material, and more preferably from 55 to 60 wt.% thereof.

[0032] Al_2O_3 is contained to improve a heat resistance of the core 2. In consideration of the heat conductivity of Al_2O_3 itself, less content is more preferable. When the balance of the heat resistance and heat conductivity is considered, the recommendable amount of Al_2O_3 to be added ranges 10 to 20 wt.%. If an amount of Al_2O_3 of is less than 10 wt. %, the heat resistance is poor. If an amount exceeds 20 wt. %, the heat insulating property of the vacuum heat insulator 1 tend to degrade.

[0033] On the other hand, CaO serves to adsorb moisture, and an added amount of 10 to 20 wt. % of CaO provides excellent heat insulating property. Even when the amount is increased to more than 20 wt. %, the effect is not so improved. If the amount is less than 10 wt. %, the effect of improving the performance of the vacuum heat insulator 1 by moisture adsorption is not recognized.

[0034] The addition of MgO is effective in improving mutual cohesive force of the fibers. Particularly when fiber sheets are produced by wet paper forming method, the addition of MgO is more effective. With addition of 1 to 4 wt. % of MgO, improvement in cohesive force is recognized, and with an amount exceeding 4 wt. %, the effect remains the same. When the added amount of MgO is reduced, the cohesive force decreases. Therefore, addition of 1 to 4 wt. % of MgO is preferable.

[0035] The material compositions of the fiber used for core 2 are described as above. Because the diameter and a bulk density of the fiber also influence the heat insulating property of the vacuum heat insulator 1, optimum physical properties should be specified.

[0036] As for the fiber diameter of the core 1, 1 to 3 μm is preferable. For a fiber diameter smaller than 1 μm, manpower in production of the fibers remarkably increases. Moreover, as a special equipment for producing fibers themselves is required, industrially economical production becomes difficult. In addition, fibers are

excessively entangled with each other to form large fibrous aggregates and thus large pores are formed. This increases the gas heat conductivity based on gas heat conduction, thus degrading the heat insulating property.

[0037] When the fiber diameter is larger than 3 μm, pores formed by aggregation of the fibers are large. For this reason, the heat conduction by gases gives greater influence; thus, the heat insulating property degrades. In order to inhibit the heat conduction by gases, a degree of vacuum of approximately 13 Pa, which allows efficient industrial production, is insufficient, and a degree of vacuum of approx. 0.13 Pa is required. But, an efficient industrial production is difficult.

[0038] Therefore, in consideration of industrial productivity, a fiber diameter ranging from 1 to 3 μm is suitable. A fiber diameter ranging 2 to 3 μm is more preferable.

[0039] On the other hand, even the material having such a fiber diameter range may adversely affect the heat insulating property of the vacuum heat insulator if the bulk density of the fiber itself is not appropriate. When the bulk density of the fiber is higher than 0.3 g/cm^3, the solid heat conduction of the fiber itself gives greater influence, and degrades the heat insulating property. In addition, such a high bulk density reduces flexibility of the heat insulator imparted by the use of a fiber material, thus making the heat insulator unsuitable for an application to protruded and recessed portions. The application against such portions is one of the characteristic features of the present invention.

[0040] When the bulk density of the fiber is lower than 0.1 g/cm^3, the proportion of the fibers in a given space reduces and air gap increases. This results in an increase of the gas heat conduction, thus degrading the heat insulating property of the vacuum heat insulator. Another problem is that atmospheric compression at a time of production of the vacuum heat insulator increases the degree of deformation and makes it difficult to produce a vacuum heat insulator of stable shape.

[0041] As a result, the bulk density of a fiber material suitable for the vacuum heat insulator preferably ranges from 0.1 to 0.3 g/cm^3, and more preferably from 0.1 to 0.2 g/cm^3.

[0042] In order to form fibers into a sheet, it is desirable to bind the fibers using a binder. However, inappropriate type of the binder or an amount of the binder affects the heat insulating property of the vacuum heat insulator.

[0043] For example, using of an inorganic material as a binder results in a high density of the sheet. Even with organic binders, thermosetting resins, such as phenolic resin, cause gasification of unreacted monomers in a vacuum atmosphere. The gasification degrades the degree of vacuum, thus adversely affecting the heat insulating property of the vacuum heat insulator.

[0044] On the other hand, when thermoplastic resins are used as a binder, the above adverse effect caused by unreacted monomers can be reduced. When the sheets are produced by the wet paper forming method, a use of water-soluble polymers is preferable. From such a viewpoint, water-soluble acrylic resins are suitable. Being water-soluble polymers, the water-soluble acrylic resins can uniformly disperse on the surface of fibers, even when a sheet is produced by the method. Thus, a fibrous sheet having uniform bonding strength can be obtained.

[0045] Even when the water-soluble acrylic resins are used as a binder, the amount to be added is an important factor. For an amount of less than 3 wt. %, a sheet of fibers can be formed but is broken when wound like a roll. Thus, stable production is difficult. For an amount exceeding 10 wt. %, the viscosity of the slurry used in production by the wet paper forming method is high, thus deteriorating the productivity.

[0046] For these reasons, the suitable amount of the acrylic binder to be added ranges from 3 to 5 wt. %. An amount from 3 to 4 wt. % is more preferable.

[0047] However, when the productivity of the sheets of fibers can be neglected, excellent heat-insulating property as a vacuum heat insulator can be obtained even using no binder.

[0048] Hereinafter a specific method of producing the vacuum heat insulator 1 of the present invention is described.

[0049] The core 2 of the above structure is dried in a drying oven at a temperature of 130 °C for one hour. Thereafter, enveloping member 3 is filled with the core together with adsorbent 4, evacuated, and then sealed to form vacuum heat insulator 1.

[0050] A heat conductivity of the vacuum heat insulator 1 obtained in this manner ranges 0.0035 to 0.0038 W/mK at an average temperature of 24 °C. It has proved that the value is approximately twice as excellent as those of a conventional vacuum heat insulator using silica power and a vacuum heat insulator using an open-pored urethane foam.

Second Embodiment

[0051] Fig. 6 is a perspective view of a refrigerator in accordance with a second embodiment of the present invention. Refrigerator 5 of the present embodiment uses, as heat insulator 1, the vacuum heat insulator described in the first embodiment. The refrigerator 5 has a freezer compartment 6 at a bottom and a machine room 7 at a back bottom portion. A refrigerant piping 8 is attached to outer box 9 with aluminum tapes. A rigid urethane foam (not shown) using cyclopentane as a foaming agent is filled in a space between an inner box (not shown) and outer box 9. On both side faces of a freezer compartment 6 of the refrigerator 5, vacuum heat insulator 1 produced in accordance with the first embodiment is provided. Between the vacuum heat insulator 1 on the sidewalls of the freezer compartment and outer box 9 to which the vacuum heat insulator is to be attached, high-temperature refrigerant piping 8 is

provided. Moreover, the heat insulator 1 is shaped to substantially cover the sidewalls of the freezer compartment. Furthermore, the aluminum foil side of the composite film of the vacuum heat insulator 1 is placed on a side exposed to the high-temperature refrigerant piping 8.

[0052] This structure allows efficient heat insulation of the sidewalls of the freezer compartment and inhibits entry of the heat from the high-temperature refrigerant piping into the freezer compartment, thus providing a refrigerator having low power consumption. Moreover, this structure can also inhibit the degradation of the heat insulating property caused by liquefaction and decrease of a urethane blowing agent that occurs when it is cooled to a temperature of - 18 °C.

[0053] In addition, the refrigerator 5 of the present invention also has the vacuum heat insulator 1 between machine room 7 and the freezer compartment 6. The temperature is highest in machine room 7 because the compressor operates therein. Therefore, the use of the vacuum heat insulator 1 is effective.

[0054] Having flexibility, the vacuum heat insulator 1 of the present invention can be applied along the stereoscopic shape of the machine room. Moreover, having high heat resistance, the vacuum heat insulator 1 can be used for the space between the machine room 8 and the freezer compartment 6, and can be provided in a machine room. Thus, a refrigerator excellent in energy saving and cost-performance can be provided.

Third Embodiment

[0055] Fig. 7 is a sectional view of a heat insulation box in accordance with a third embodiment of the present invention. The heat insulation box 101 forming a refrigerator uses vacuum heat insulator 1 of the first embodiment. The heat insulation box 101 comprises an inner box 102 of a vacuum-molded ABS resin, an outer box 103 of a press-molded iron sheet, and a flange 104. To form the heat insulation box 101, the vacuum heat insulator 1 is provided inside of the box beforehand and then rigid urethane foam 106 is filled and foamed into a space other than the vacuum heat insulator 1.

[0056] Fig. 8 is a schematic view of the heat insulation box 101. Atop wall of the heat insulation box is provided with one sheet of the vacuum heat insulator 1, a back wall one sheet, and side walls two sheets. According to the shape of the heat insulation box 1, the sheet of vacuum heat insulator 2 used for each side wall is cut along one side to fit to a shape of the sidewall.

Fourth Embodiment

[0057] Fig. 9 is a schematic view of a heat insulation box in accordance with an example of the present embodiment.

[0058] Heat insulation box 108 is used as a cooler, and comprises a box 109 and lid 110.

[0059] Fig. 10 is a schematic view of a box in accordance with another example of the present embodiment.

[0060] Box 109 is integrally molded by adhering the vacuum heat insulator 1 onto an inner surface of an outer box 102 using double-sided adhesive tapes in a space formed by the inner box 111 and the outer box 112 made of polypropylene, and thereafter filling and foaming the space between inner box 111 and outer box 103 other than vacuum heat insulator 1 with rigid urethane foam 106.

[0061] Fig. 11 is a schematic view of a lid in accordance with still another example of the present embodiment.

[0062] The vacuum heat insulator 1 including the adsorbent 4 is disposed in a foamed polystyrene 113, and packed in a space formed by an inner frame 114 and an outer frame 115.

[0063] With reference to Fig. 10, vacuum heat insulator 1 is made by bending a sheet of vacuum heat insulator into the C-shape to fit to a shape of heat insulation box 109.

[0064] Having a sheet-form core, vacuum heat insulator 1 can be bent into the C-shape easily. This improves a coverage of the vacuum heat insulator 2 on the heat insulation box 9, thus improving the heat insulating property of the heat insulation box 109.

[0065] With reference to Fig. 11, lid 110 comprises a foamed polystyrene 113 having a recess that has been formed to fit to the shape of the vacuum heat insulator, and the vacuum heat insulator 1 buried into the recess. The polystyrene is placed in a space formed by the inner frame 114 and the outer frame 115 made of polypropylene.

[0066] As the vacuum heat insulator 1 used for lid 110 is smaller than the vacuum heat insulator used for the box 109, a ratio of areas of sealing portions in the enveloping member increases in the vacuum heat insulator 1. This is considered to give greater influence of gases entering from the sealing portions of the enveloping member with·long period time, and increases an aged degradation of the performance of the vacuum heat insulator, and thus degrade the heat insulating property. For this reason, adsorbent 4 is used for the vacuum heat insulator 1 for the lid 110.

[0067] It is desirable to use an adsorbent 4 that is made of a room temperature activation type getter material for adsorbing and removing at least nitrogen, oxygen, moisture, and carbon dioxide. Specific examples include an oxygen adsorbent essentially consisting of iron powder, which is commercially available under a trade name of AGELESS, for example.

Fifth Embodiment

[0068] Fig. 12 is a sectional view of a heat insulation box of the present embodiment.

[0069] Heat insulation box 118 forming a refrigerator comprises an inner box 119 of a vacuum-molded ABS

resin, and an outer box 120 of a press-molded iron sheet. Vacuum heat insulator 1 is provided between the inner box 119 and the outer box 112, and the space other than vacuum heat insulator 1 is filled and foamed with rigid urethane foam 121.

[0070] A thermoplastic resin 122 is applied to an inner surface of the outer box 120 beforehand so as to fit to an outer periphery of core 2 and have a width of 10 mm. Thermoplastic resin 122 is heat-sealed to the heat seal layer of the enveloping member 3 of the vacuum heat insulator 1. Desirable thermoplastic resins include high-density polyethylene, low-density polyethylene, and polypropylene.

[0071] In the present embodiment, because a laminated sheets of an inorganic fiber that is light, excellent in surface planarity, and thin is used as the core, an adhesive property between the vacuum heat insulator and the inner surface of the outer box is excellent. This improves the heat insulating property. In addition, being light and thin, the vacuum heat insulator is not displaced by its own weight when attached to the inner surface of the outer box. Furthermore, having a thin core, the vacuum heat insulator 1 does not hinder the fluidity of the rigid urethane foam when it is filled into the space between the inner box 119 and the outer box 112 and foamed. Thus, the rigid urethane foam can be uniformly filled without forming any void. Therefore, the heat insulating property of the entire heat insulation box improves.

Sixth Embodiment

[0072] Fig. 13 is a sectional view of a refrigerator in accordance with an exemplary embodiment of the present invention.

[0073] Heat insulation box 201 comprises an inner box 202 of a vacuum-molded ABS resin and outer box 103 of a press-molded iron sheet, which are engaged with each other via a flange. Vacuum heat insulator 1 is provided inside of the box 201 beforehand, and then rigid urethane foam 204 is filled into the space other than the vacuum heat insulator and foamed.

[0074] Heat insulation box 201 is horizontally divided by a partition 205. The upper part forms a refrigerator compartment and the lower part forms a freezer compartment. Two evaporators 206 are provided. One is used for cooling the refrigerator compartment and another is used for cooling the freezer compartment.

[0075] In addition, a compressor 208, a control circuit board 209, and a condenser 200 are disposed in a machine room 207 at the bottom of the refrigerator. The evaporator 206 for cooling the freezer compartment is disposed outside of the machine room and inside of the inner box 202. The heat insulation box 201 is formed so as to house the evaporator in this manner.

[0076] Because the vacuum heat insulator 1 of the present invention has excellent heat insulating property, even a thin sheet of the vacuum heat insulator 1 can provide sufficient heat insulation, thus greatly contributing to increasing the volume of the storage space in the refrigerator. Especially, although the disposing of the two evaporators decreases a volume of the refrigerator compartment in the present embodiment, the use of the thin and excellent vacuum heat insulator 1 can inhibit the decrease in the volume of the storage space in the refrigerator.

[0077] A disposing a plurality of sheets of vacuum heat insulator 1 on the back, side, and top walls of the refrigerator can further increases the volume of the storage space in the refrigerator. However, the disposing of a large number of vacuum heat insulator 1 may increase the cost.

[0078] As for a method of disposing the vacuum heat insulator of the present embodiment, the vacuum heat insulator 1 is attached to the inside of the outer box 203 with a double-sided adhesive tapes or the like, and thereafter the space between the inner box 202 and outer box 203 is filled and foamed with a rigid urethane foam 204.

[0079] In addition, for the refrigerator of the present embodiment, the heat insulating part in partition 205 is also integrally filled with rigid urethane foam 204. The vacuum heat insulator 1 is also disposed in partition 205 to reduce a thickness of the partition. This contributes to increasing the volume of the storage space in the refrigerator.

[0080] In the present embodiment, the upper part of the heat insulation box 201 divided by the partition 205 is a refrigerator compartment, and the lower part is a freezer compartment. The refrigerator compartment may be further divided to provide a refrigerator compartment and a crisper, for example. The freezer compartment may be further divided to provide a freezer compartment, ice-maker, and partially freezing compartment.

[0081] The vacuum heat insulator 1 provided in a heat insulating part for separating machine room 207 and the freezer compartment is bent and shaped to fit to the machine room 207. Using the sheet-shape core, the vacuum heat insulator 1 can be bent easily with excellent productivity. When a plurality of sheets of the vacuum heat insulator are combined for insulation in a conventional manner, a gaps between each sheet of the vacuum heat insulator cause degradation of the heat insulating property. In contrast, as shown in the present invention, the use of a sheet of the vacuum heat insulator that can be bent results in an improvement in heat insulating property that leads to an energy saving by a shorter operating time of the compressor 208.

[0082] In the present embodiment, the freezer compartment, the compressor 208, the control circuit board 209, and the condenser 200 are insulated by the vacuum heat insulator 1 at a time.

[0083] Therefore, a temperature increase in the freezer compartment caused by a heat generated from the compressor, the control circuit board, and the condens-

er can be inhibited. In the present embodiment, because each of the compressor and freezer compartment, the control circuit board and freezer compartment, and the condenser and freezer compartment need not be insulated separately, the heat insulation can be performed very efficiently.

[0084] In addition, because inorganic fibers are non-flammable, the vacuum heat insulator has a non-flammable structure and unlikely to generate toxic gases. Therefore, the refrigerator using this vacuum heat insulator is also non-flammable. For such a reason, the refrigerator is also excellent in safety.

[0085] Furthermore, even when flammable substances such as carbon-hydride are used for the refrigerator as a foaming agent of the foamed resin, refrigerant, or the like, the vacuum heat insulator has an non-flammable structure because the inorganic fibers are used. Thus, the refrigerator of the present embodiment can be a refrigerator excellent in safety.

Seventh Embodiment

[0086] Fig. 14 is a sectional view of heat insulation box 210 forming an insulation box, in accordance with the sixth embodiment of the present invention.

[0087] Insulation box 210 comprises a body 211, a lid 212, an outer box 213, an inner box 214, a cold storage unit 215, a heat insulator 216, and a vacuum heat insulator 1.

[0088] In application to the insulation box 210, because vacuum heat insulator 1 of the present invention has flexibility, it can integrally be attached to the insulation box of substantially cubic shape if it is bent beforehand. Thus, because a number of joints of vacuum heat insulator 1 can be reduced, heat leak from the joints can be reduced.

[0089] Moreover, when protrusions and recesses for housing the cold storage unit 215 are formed in the lid 212, the vacuum heat insulator 1 can be attach to the protrusions and recesses because it has flexibility. Thus, the heat insulation property can be efficiently improved.

[0090] Because the insulation box 210 of the present embodiment can sufficiently use effects of the vacuum heat insulator 1, the heat insulating property that the conventional insulation box could not provide can be obtained. Therefore, such an insulation box can be used as a medical cold-box requiring stricter temperature control, as well as a leisure cooler.

[0091] The materials of the cold storage unit 215 are not specifically limited. Commercially available general cold storage agents can be used. the insulator 216 is not specifically limited as well. Examples of the usable heat insulator include commercially available foamed resins such as a rigid urethane foam and polystyrene foam, and fiber materials such as glass wool.

[0092] Vacuum heat insulator 1 can be attached to either one of the outer box 213 and the inner box 214 in the body 211. In either case, the same effect can be obtained.

Eighth Embodiment

[0093] Fig. 15 is a sectional view of a water heater in accordance with an exemplary embodiment of the present invention. The water heater 317 comprises a body 318, a hot water reservoir 319, a lid 320, a heater 321, and vacuum heat insulators 1. The vacuum heat insulator 1 is attached so as to wind around the outside of the hot water reservoir 319. In addition, the vacuum heat insulator 1 is bent and extended to the vicinity of the heater 321. Furthermore, the vacuum heat insulator 1 is provided in a recess in the lid 320.

[0094] In the water heater 317 of such a structure, as the inorganic fiber material having high heat resistance is used as the core, the vacuum heat insulator 1 is unlikely to be degraded by heat. Thus, the heat insulator has no problem when the water heater is used even for a long period of time. Moreover, having flexibility, the vacuum heat insulator 1 can be bent, extended to the vicinity of the heater, and used in the recess in the lid.

[0095] Because the vacuum heat insulator 1 has high heat resistance and flexibility, water heater 317 of the present embodiment can efficiently reduce the power consumption and realize downsizing.

INDUSTRIAL APPLICABILITY

[0096] As described above, the vacuum heat insulator of the present invention uses laminated sheets of an inorganic fiber as the core. The heat insulation box of the present invention uses the vacuum heat insulator of the present invention. Therefore, because the vacuum heat insulator generates very little gas with time and has excellent workability, a heat insulation box excellent in long-term reliability and productivity can be obtained. In addition, the use of a thin sheet-form material as the core makes the heat insulation box thinner, thus contributing to a space saving of the heat insulation box.

[0097] Because the core used for this invention can be shaped easily, lamination and machining such as a bending and a forming of a cut-off portion, recess, or through hole can be performed easily. Therefore, a vacuum heat insulator suitable for a required heat insulation portion can be produced easily and applied to a heat insulation box, such as a refrigerator. In other words, coverage of the vacuum heat insulator in the heat insulation box increases and thus the heat insulating property of the heat insulation box also improves. In addition, the vacuum heat insulator uses a thin sheet-form core. Therefore, when used for a partition in the heat insulation box, the vacuum heat insulator can provide a thin partition, thus allowing efficient use of the space in the heat insulation box.

[0098] For these reasons, the use of the vacuum heat insulator of the present invention for the equipment re-

quiring heat insulation, such as a refrigerator, accomplish improvement in the productivity and energy saving as well as downsizing of the equipment.

Claims

1. A heat insulation box comprising:

    an inner box having an opening at least a part thereof;
    an outer box;
    a lid for closing the opening; and
    a vacuum heat insulator disposed between said inner box and said outer box, said vacuum heat insulator comprising:

        a core made of a laminate of at least two layers of a sheet-form inorganic fiber; and
        a laminated film sandwiching said core.

2. The heat insulation box according to claim 1, wherein said laminated film disposed on one side of the laminate comprising said vacuum heat insulator, and said laminated film disposed on the other side of the laminate have different lamination structures.

3. The heat insulation box according to claim 1, further comprising an adsorbent.

4. The heat insulation box according to any one of claims 1 through 3, wherein said heat insulation box is one selected from a group consisting of a refrigerator, a thermal storage box, a cold storage box, a vending machine, and a water heater.

5. The heat insulation box according to any one of claims 1 through 3, further comprising a freezer compartment at a bottom thereof and a machine room outside thereof, wherein said vacuum heat insulator covers sidewalls of said freezer compartment, and a space between said inner box and said outer box other than said vacuum heat insulator is filled with a foamed resin.

6. The heat insulation box according to claim 5, wherein high-temperature refrigerant piping is provided between said vacuum heat insulator and said outer box.

7. The heat insulation box according to claim 5, wherein said vacuum heat insulator is provided between said machine room and said freezer compartment.

8. The heat insulation box according to any one of Claims 1 through 3, wherein said lid has a protrusion and a recess inside thereof, one of a cold storage unit and thermal storage unit is attached to the protrusion and the recess, and said vacuum heat insulator is shaped to fit to the protrusion and the recess.

9. The heat insulation box according to any one of claims 1 through 3, wherein said heat insulation box further comprises a plurality of independent compartments having different temperature ranges and an evaporator for each of said compartment, and said vacuum heat insulator is disposed in a heat insulating portion behind at least one of the evaporators.

10. The heat insulation box according to any one of claims 1 through 3, wherein said vacuum heat insulator is disposed in a partition between said plurality of compartments.

11. The heat insulation box according to any one of claims 1 through 3, further comprising a compressor, wherein said vacuum heat insulator is disposed in a partition between said compressor and said inner box.

12. The heat insulation box according to any one of claims 1 through 3, further comprising a control circuit board, wherein said vacuum heat insulator is disposed in a partition between said control circuit board and said inner box.

13. The heat insulation box according to any one of claims 1 through 3, further comprising a condenser in a bottom thereof, wherein said vacuum heat insulator is disposed in a partition between said condenser and said inner box.

14. The heat insulation box according to any one of claims 1 through 3, wherein said heat insulation box has a thermoplastic resin layer on at least a portion of an inner surface of a space between said outer box and said inner box, and said vacuum heat insulator is adhered to said heat insulation box with the thermoplastic resin layer by a hot melt bonding.

15. The heat insulation box according to any one of claims 1 through 3, wherein said inner box is a hot water reservoir.

16. The heat insulation box according to claims 15, wherein said vacuum heat insulator is provided in a space in said lid, and said vacuum heat insulator is shaped to fit to a shape of a lower portion of said lid.

17. A vacuum heat insulator comprising:

    a core made of a laminate of at least two layers of a sheet-form inorganic fiber; and
    a laminated film sandwiching said core.

18. The vacuum heat insulator according to claim 15, wherein said inorganic fiber comprises SiO_2 as a main component, Al_2O_3, CaO, and MgO.

19. The vacuum heat insulator according to claim 17, wherein said inorganic fiber has a fiber diameter ranging from 1 to 5 µm and a bulk density ranging from 0.1 to 0.3 g/cm^3.

20. The vacuum heat insulator according to claim 17, wherein said inorganic fiber is formed in sheet-form using a binder made of a thermoplastic resin, said thermoplastic resin being an acrylic resin, and an added amount of said thermoplastic resin ranging from 3 to 10 wt. % of said sheet-form inorganic fiber.

21. The vacuum heat insulator according to claim 20, wherein said thermoplastic resin is an acrylic resin.

22. The vacuum heat insulator according to claim 17, wherein a cut-off portion is provided in a part of said sheet-form inorganic fiber.

23. The vacuum heat insulator according to claim 22, wherein an adsorbent is disposed in said cut-off portion.

24. The vacuum heat insulator according to claim 17, wherein a recess is provided in at least one portion of said sheet-form inorganic fiber.

25. The vacuum heat insulator according to claim 17, wherein a through hole is provided in at least one portion of said sheet-form inorganic fiber.

FIG. 1

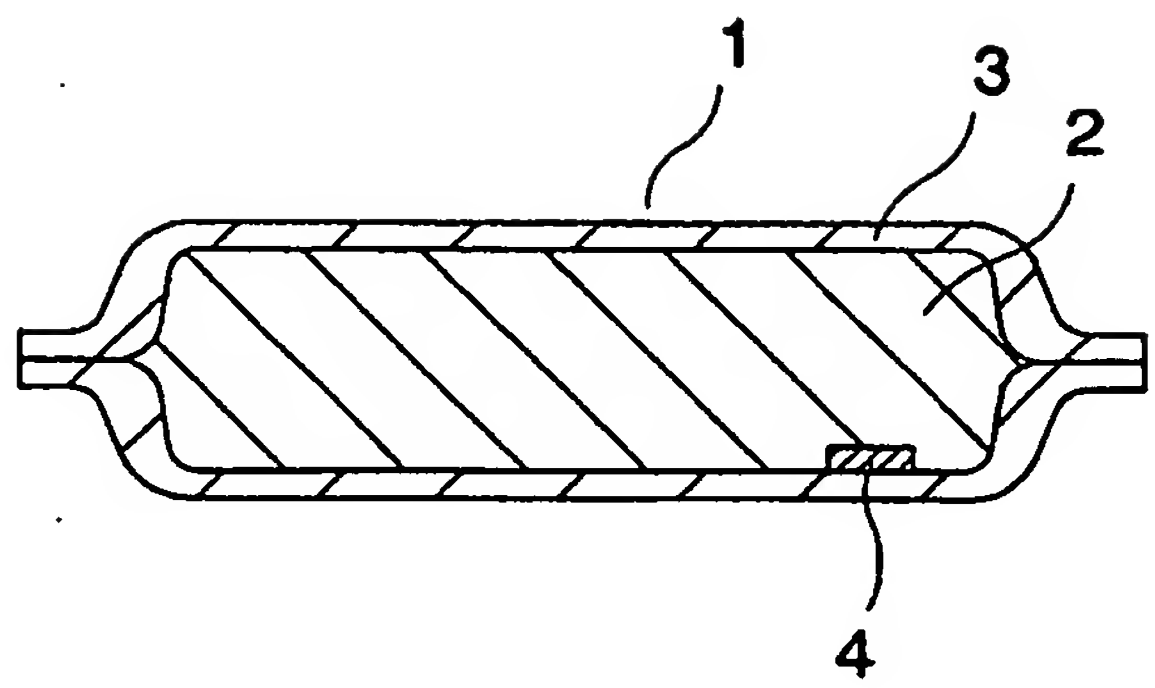


FIG. 2

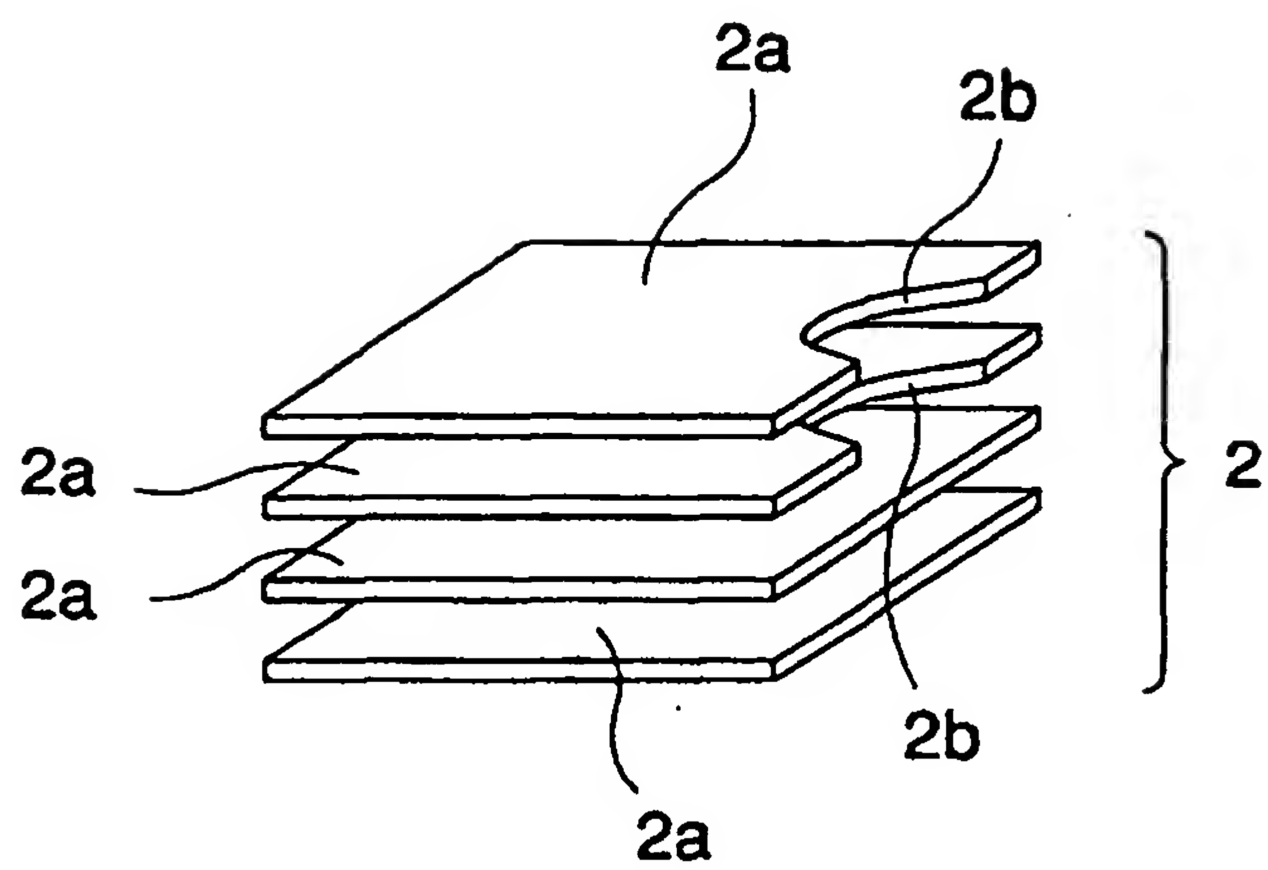


FIG. 3

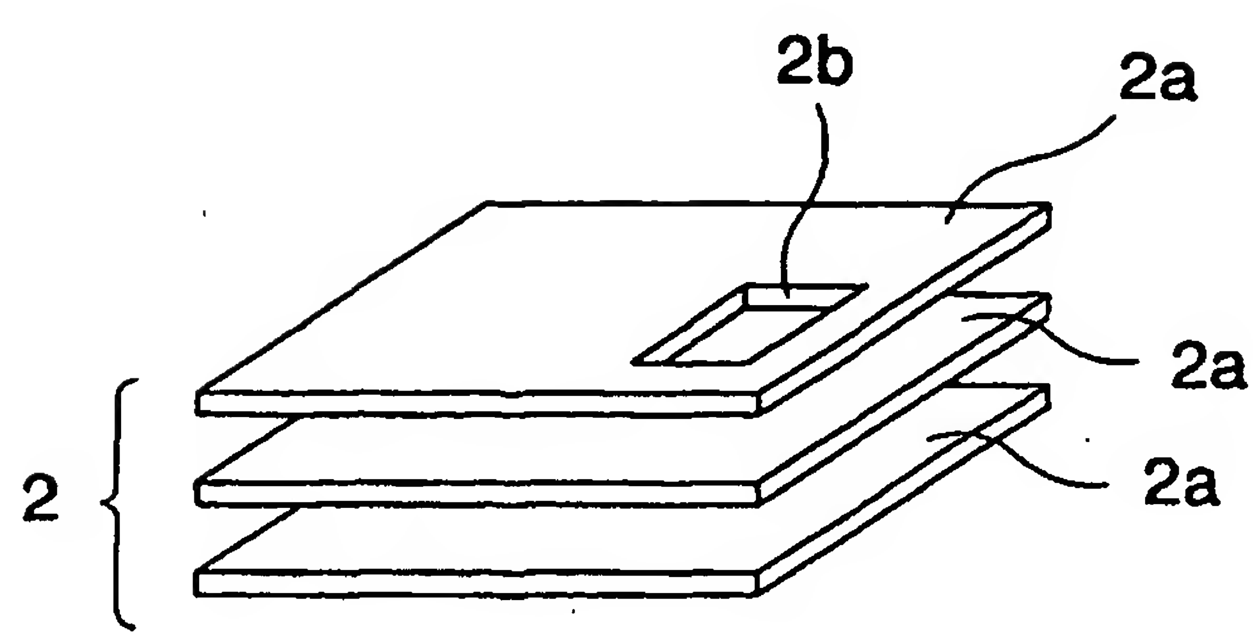


FIG. 4

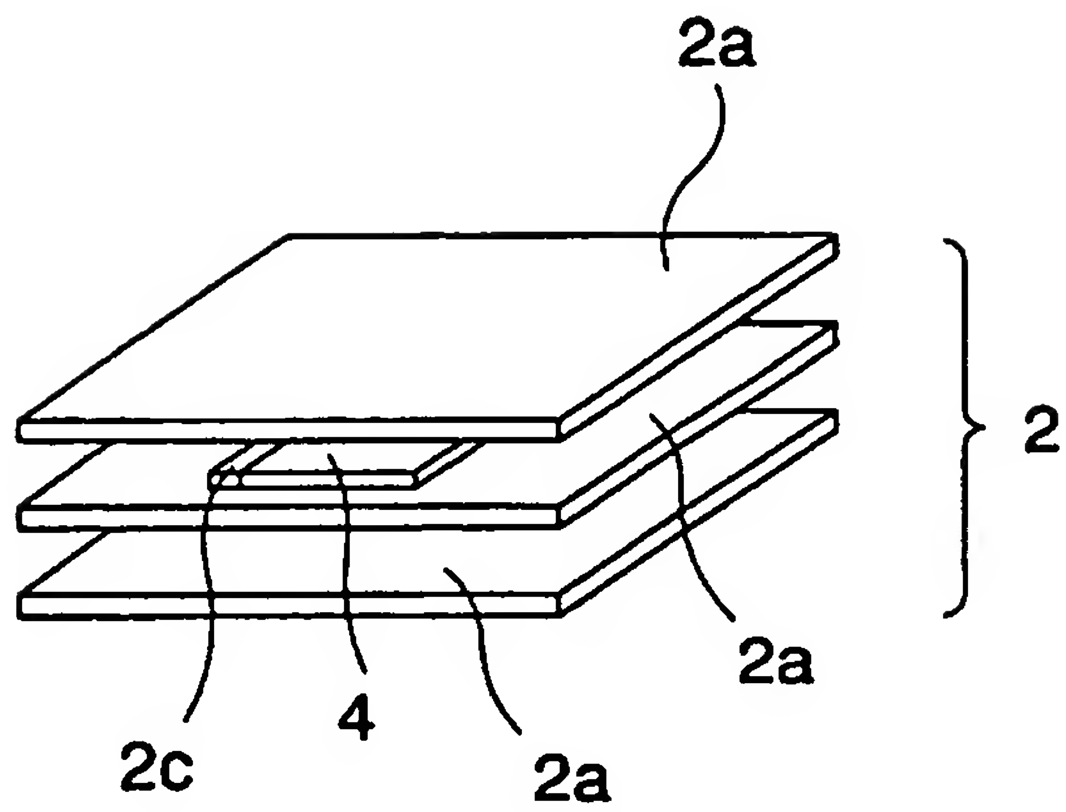


FIG. 5

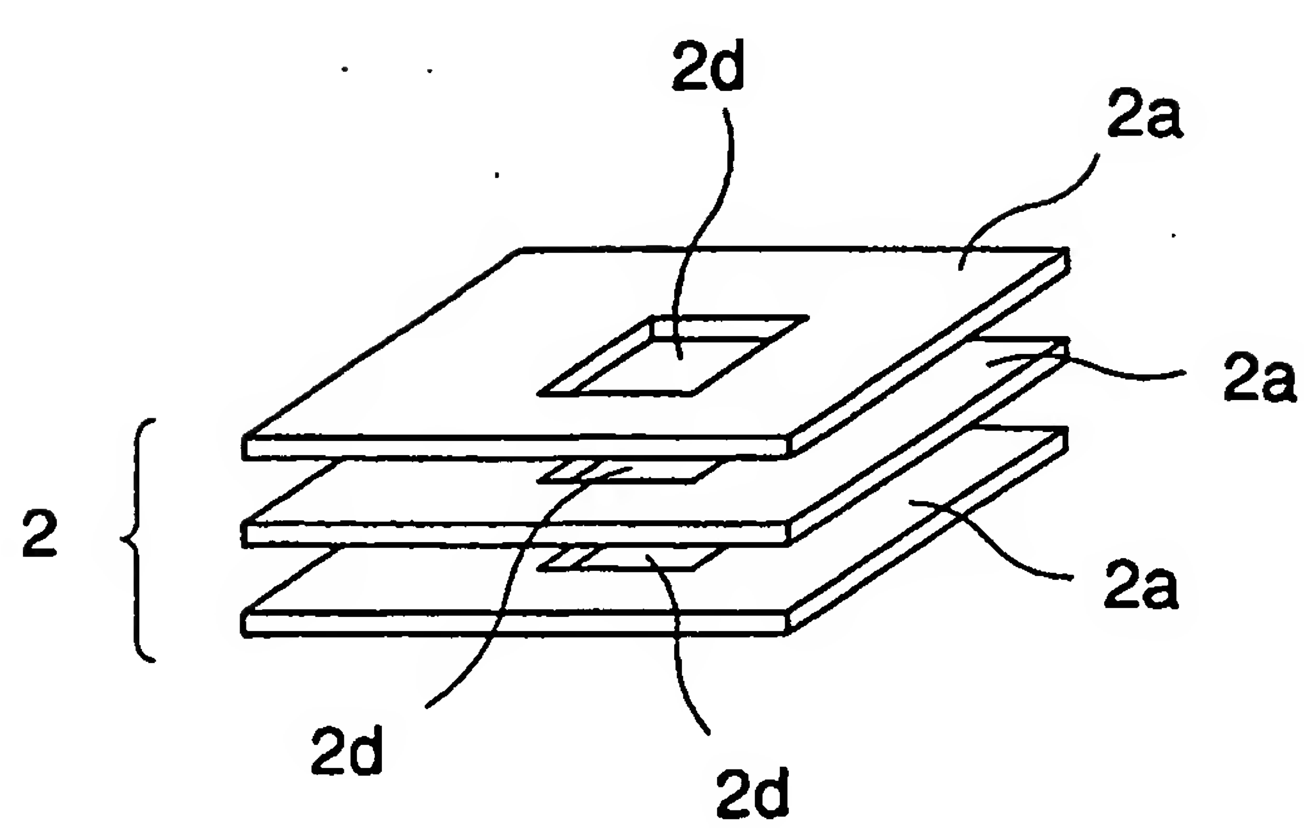


FIG. 6

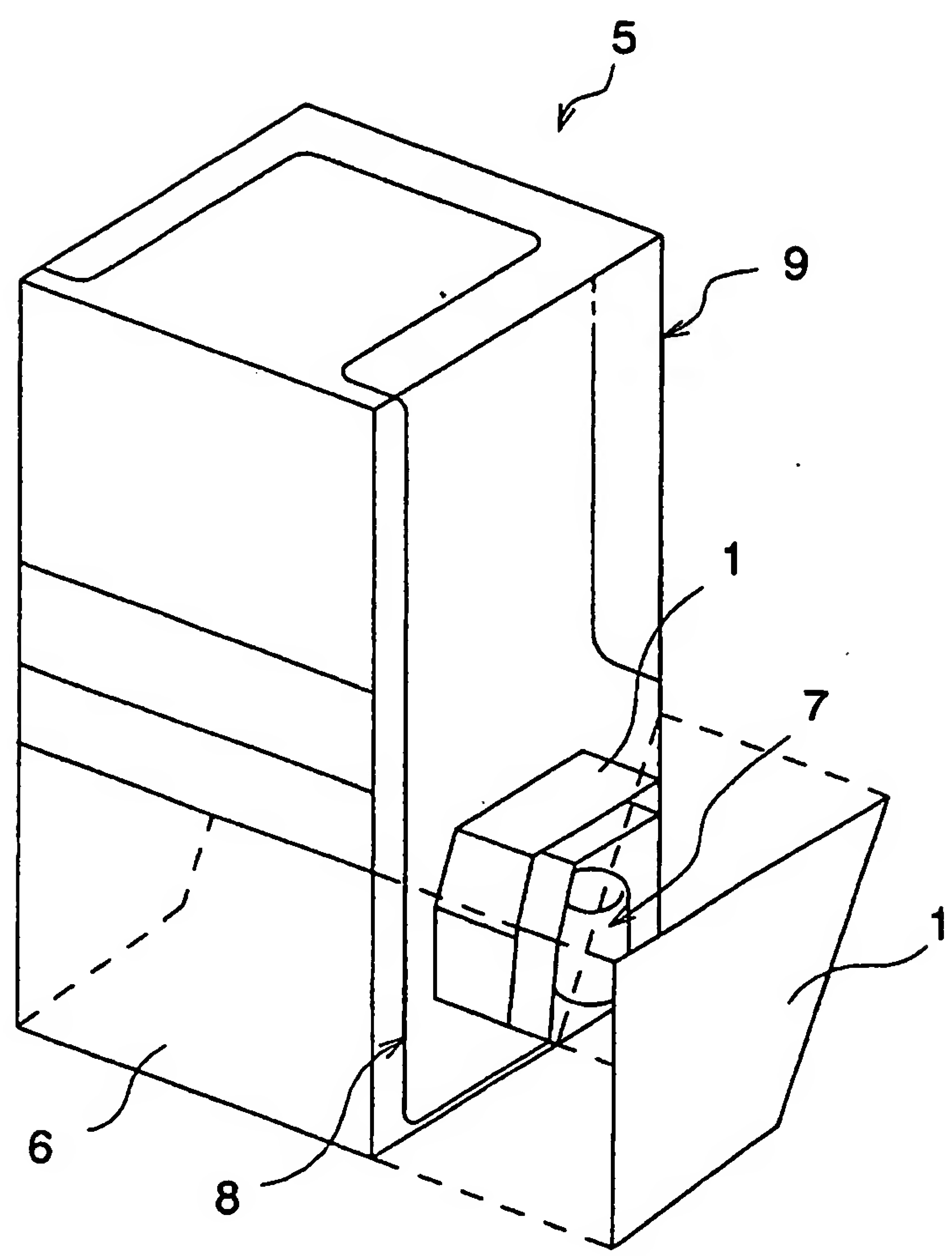


FIG. 7

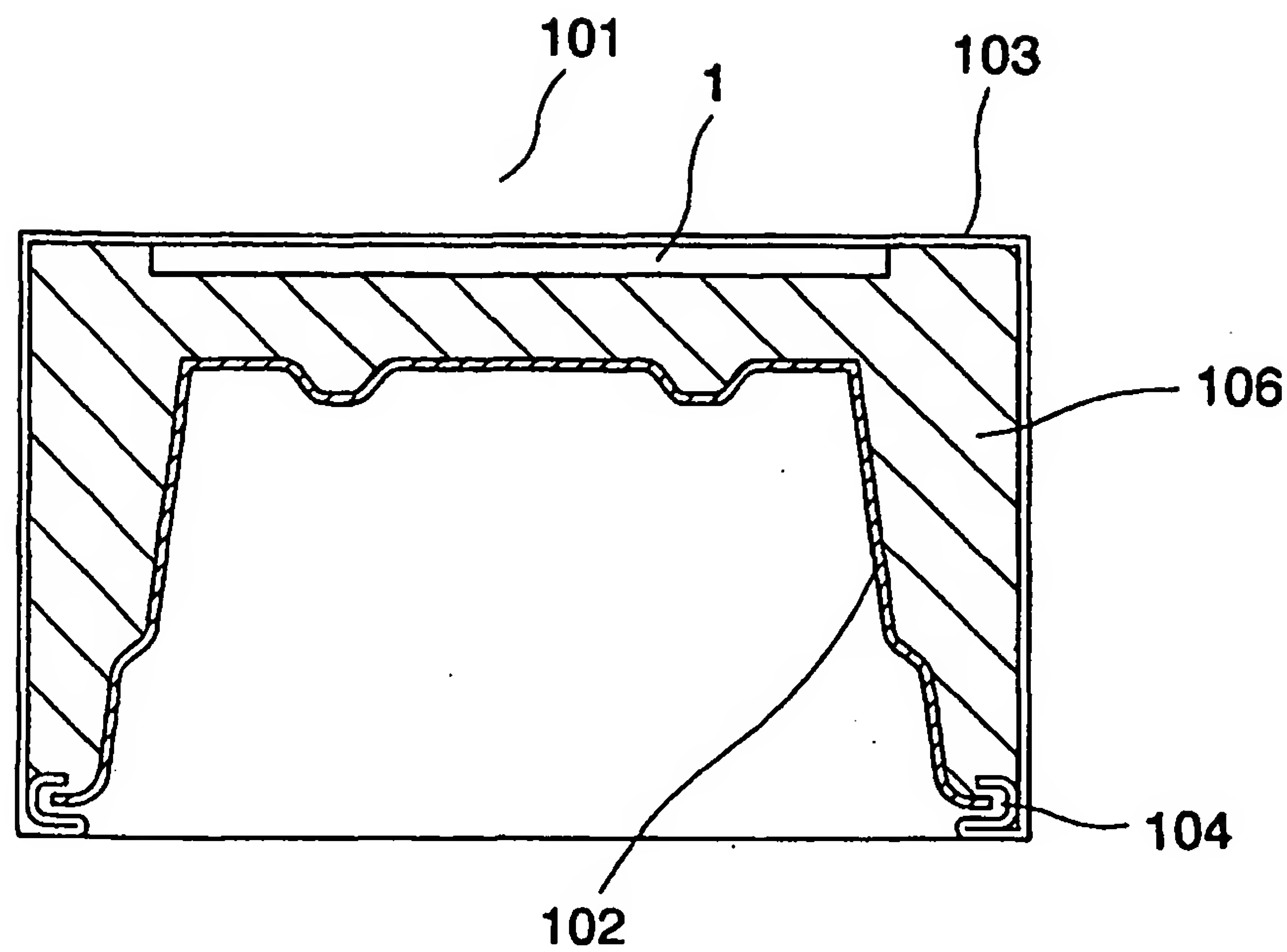


FIG. 8

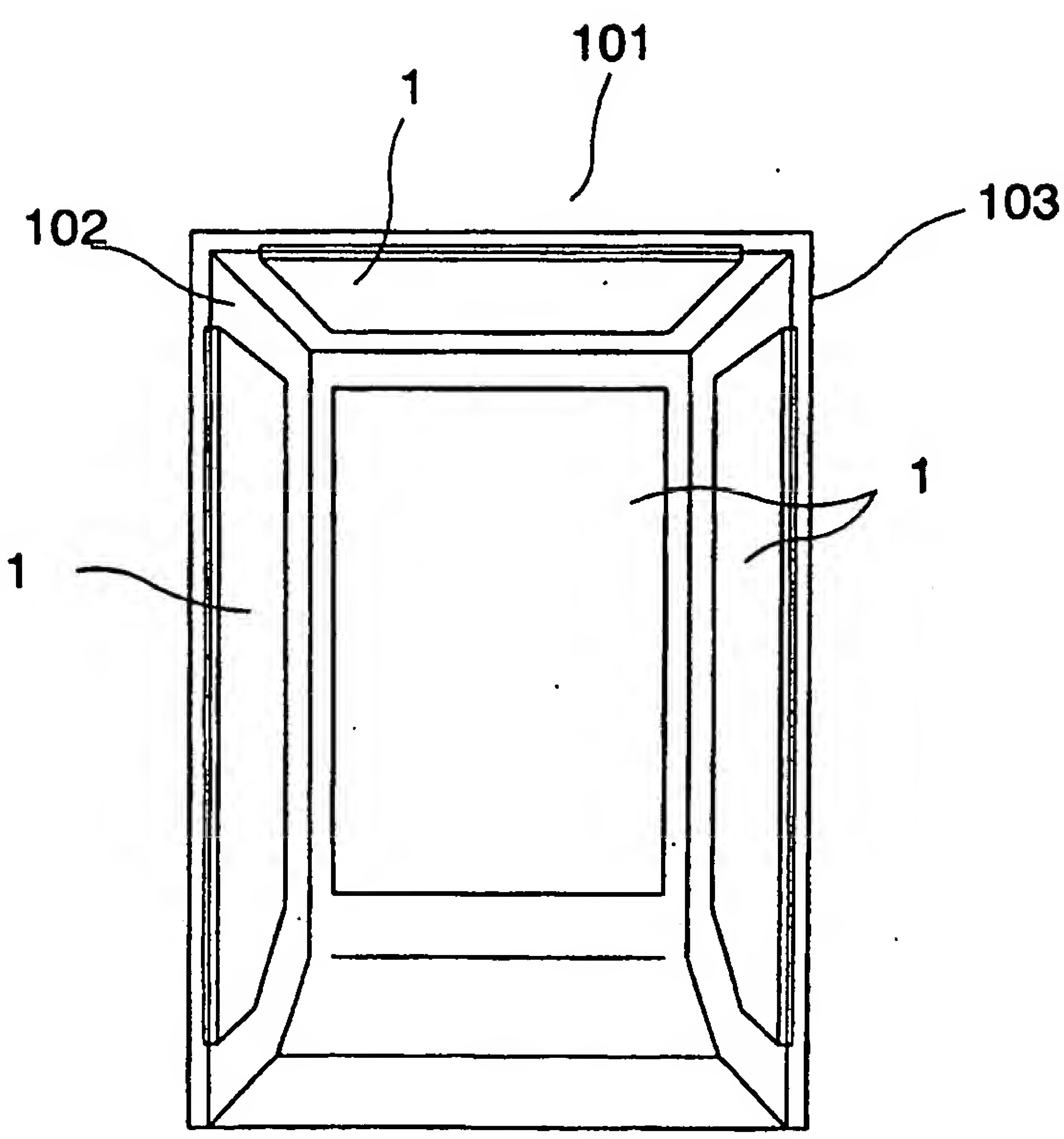


FIG. 9

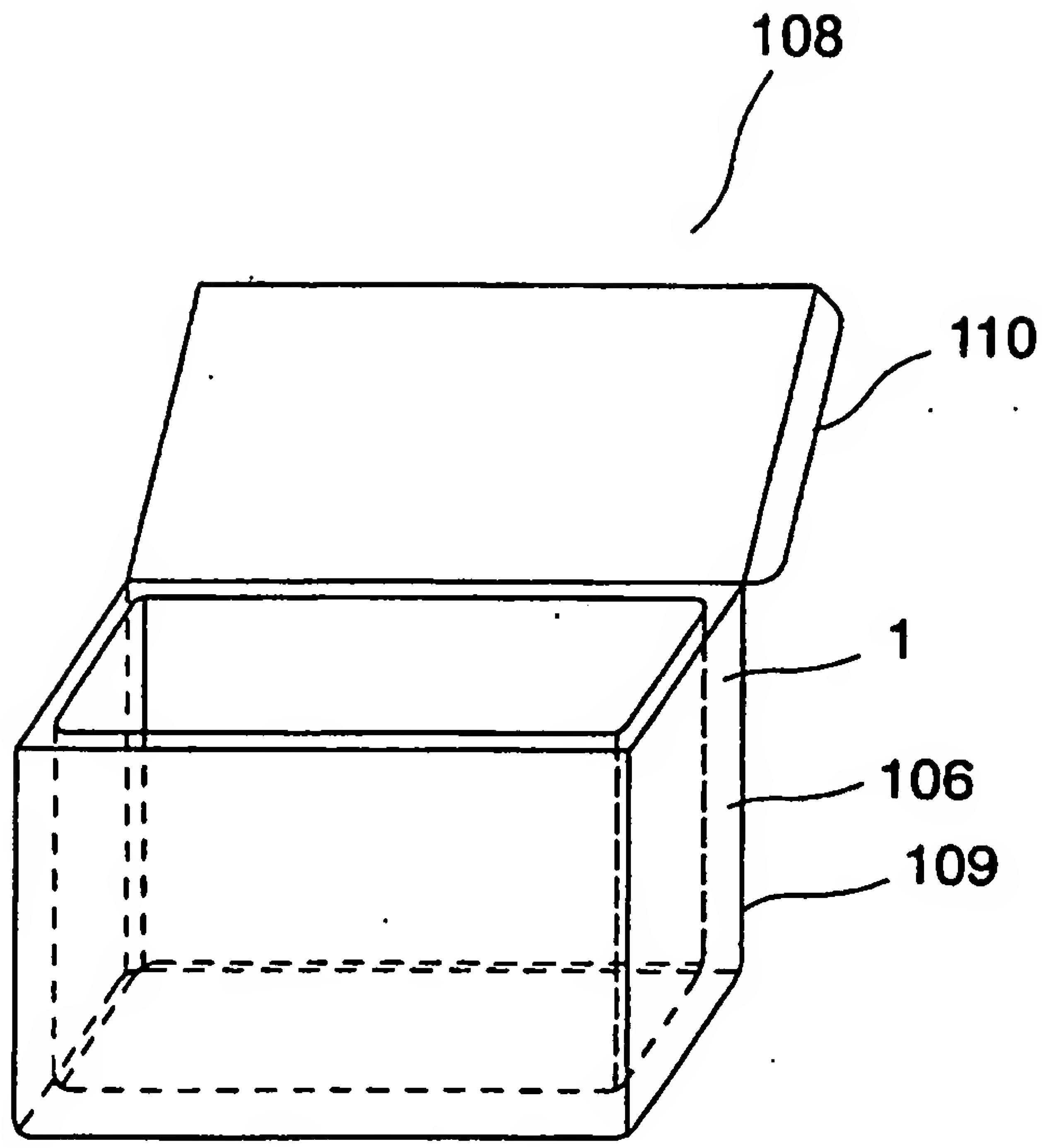


FIG. 10

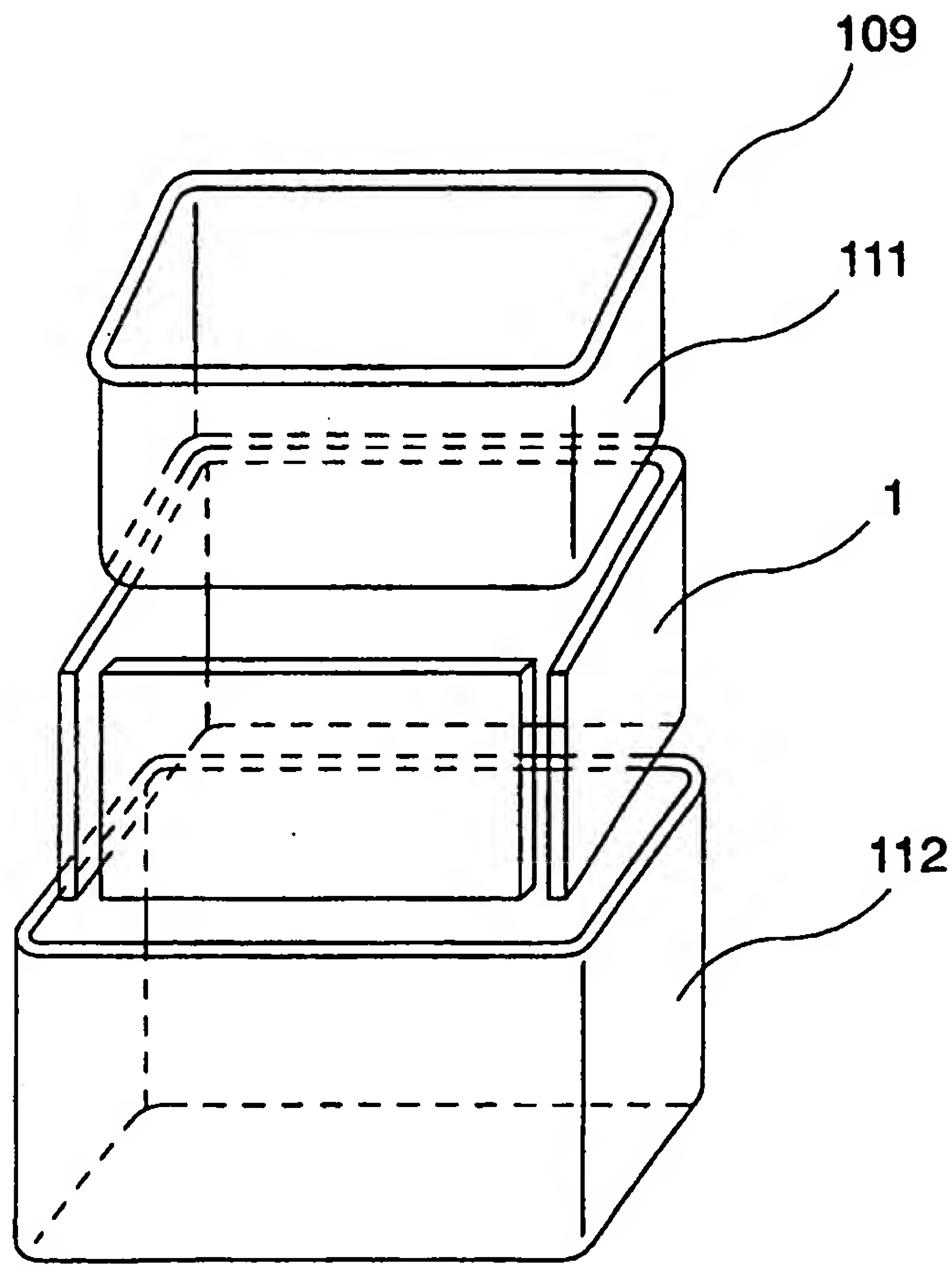


FIG. 11

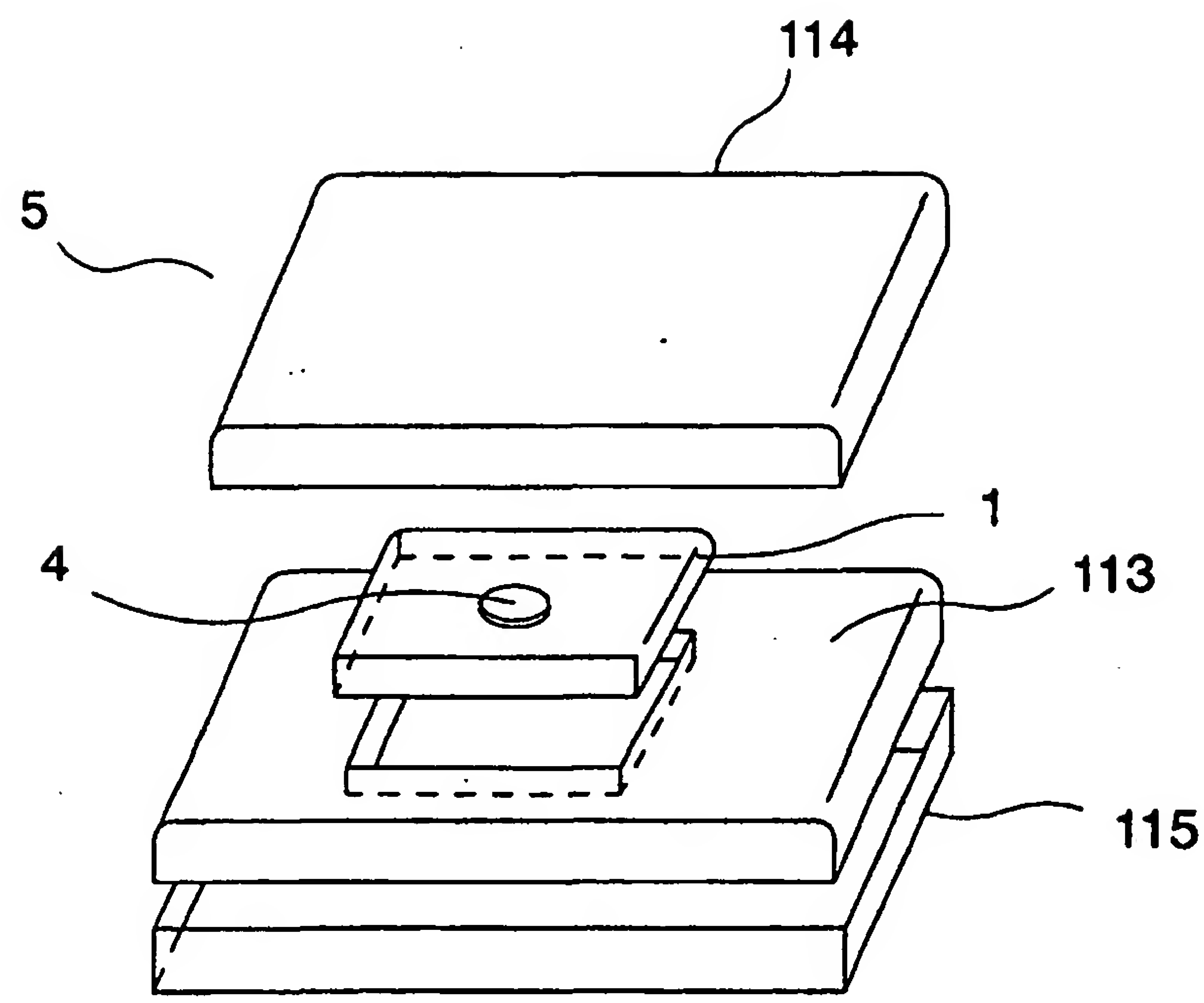


FIG. 12

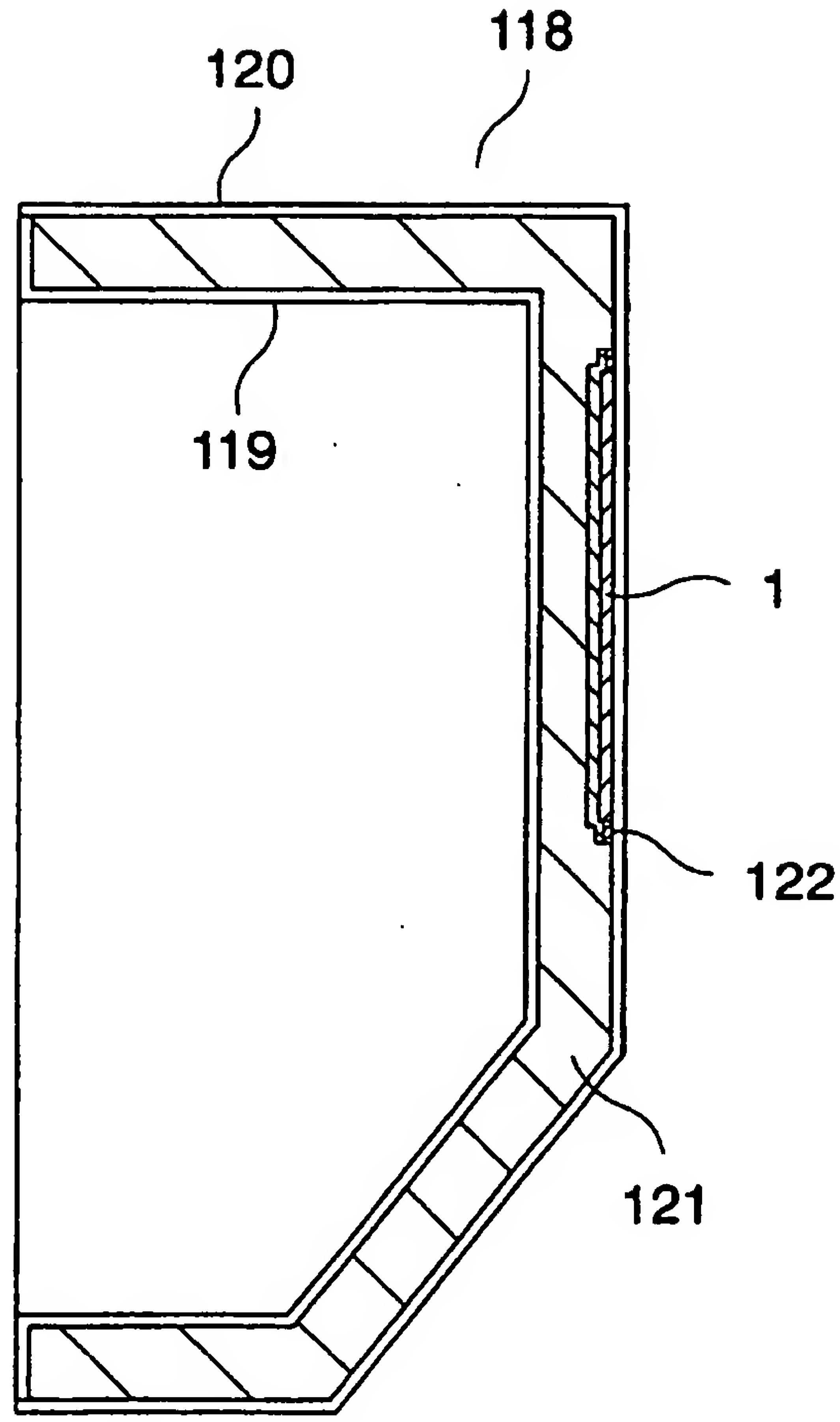


FIG. 13

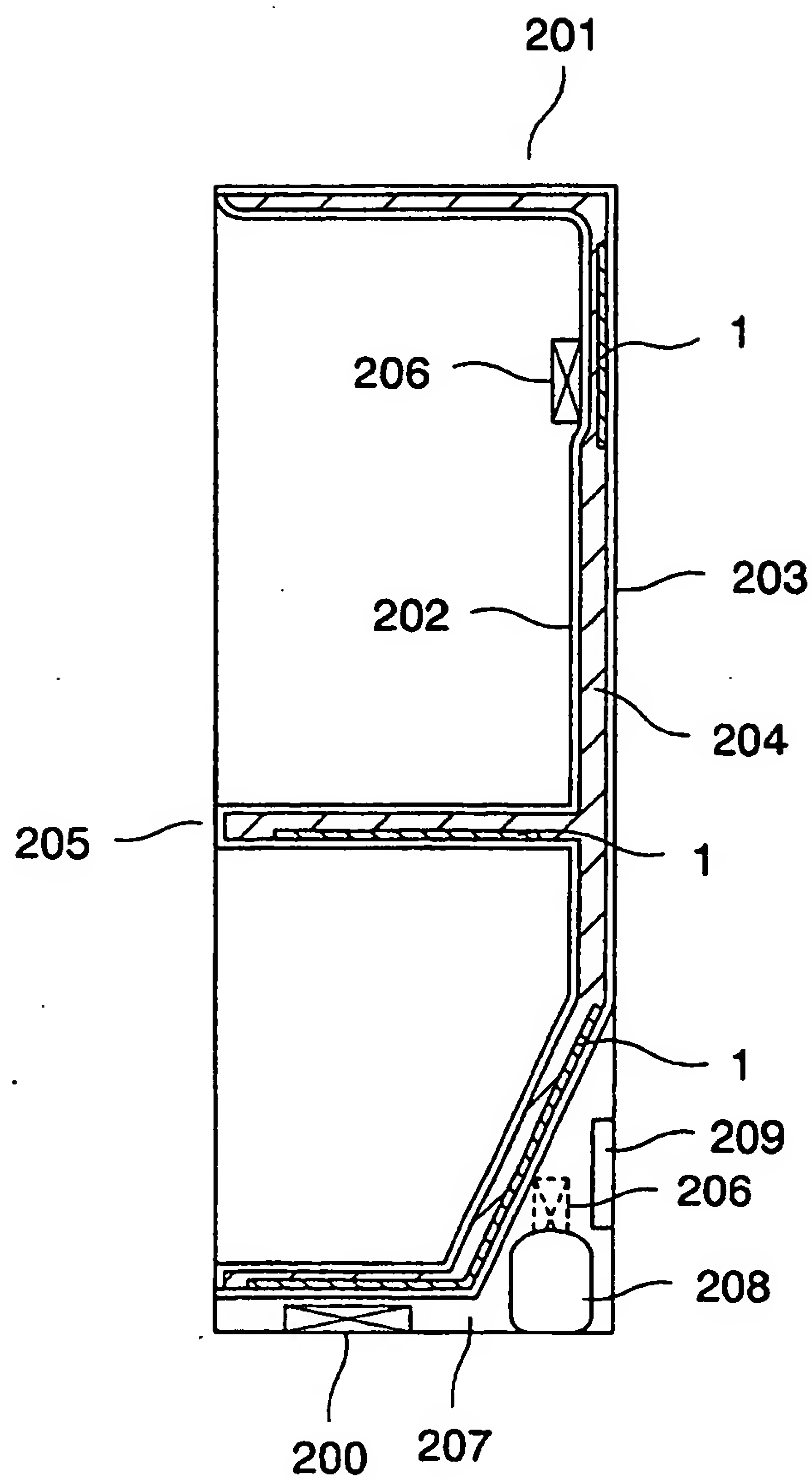


FIG. 14

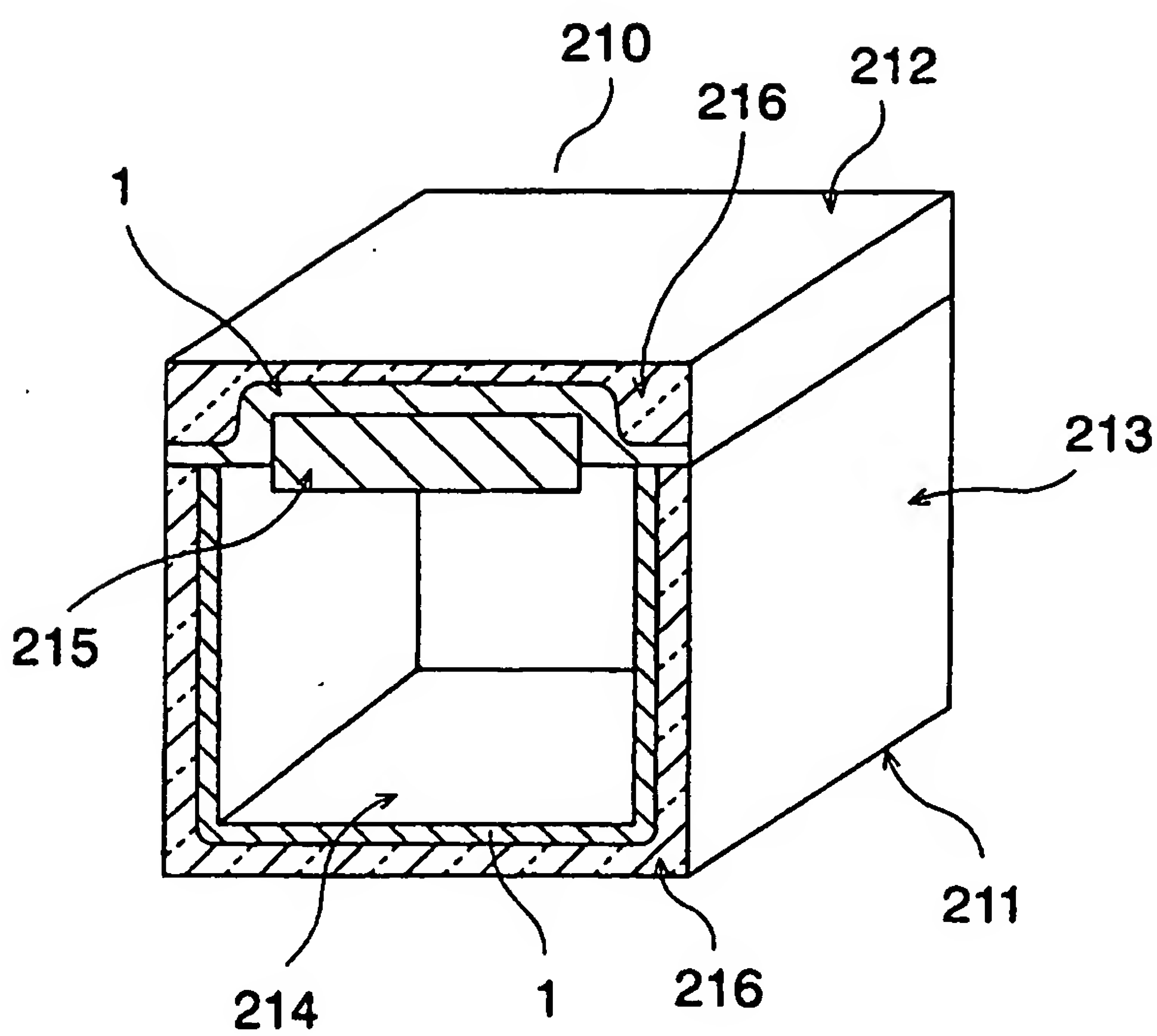
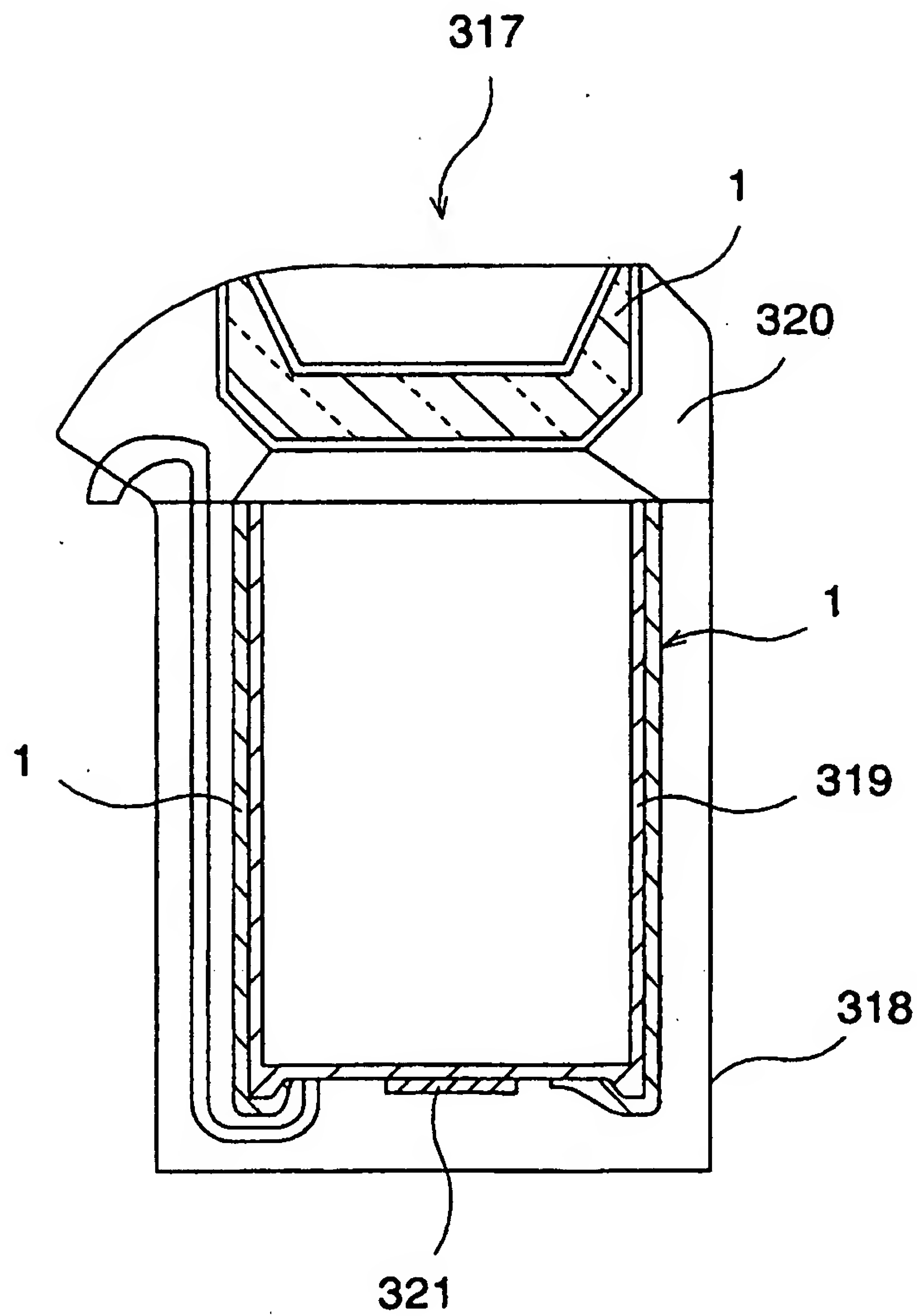


FIG. 15



Reference Numerals

1	Vacuum heat insulator
2	Core
2a	Sheet-form inorganic fiber
2b	Cut-off portion
3	Enveloping member
4	Adsorbent
5	Refrigerator
6	Freezer compartment
7	Machine room
8	Refrigerant piping
9, 103, 112, 120, 203, 213	Outer box
101, 108, 201	Heat insulating box
102, 111, 119, 202, 214	Inner box
104	Flange
106、121、204	Rigid urethane foam
109	Box part
110, 212	Lid
113	Foamed polystyrene
114	Inner frame
115	Outer frame
118	Heat insulating box (refrigerator)
122	Thermoplastic resin
200	Condenser
205	Partition
206	Evaporator
207	Machine room
208	Compressor
209	Control board
210	Insulating box
211	Body
215	Cold storage unit
216	Heat insulating material
317	Water heater
318	Body
319	Hot water reservoir
320	Lid
321	Heater

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/09388

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 F16L59/06, F25D23/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 F16L59/06, F25D23/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2001
Kokai Jitsuyo Shinan Koho	1971-2001	Jitsuyo Shinan Toroku Koho	1996-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP, 9-133289, A (KUBOTA Corporation), 20 May, 1997 (20.05.97), Full text; Figs. 1 to 3 (Family: none)	1-8,10, 15-21 9,11-14, 22-25
Y A	JP, 8-303683, A (KUBOTA Corporation), 22 November, 1996 (22.11.96), Full text; Figs. 1 to 10 (Family: none)	1-8,10, 15-21 9,11-14, 22-25
Y	JP, 4-266697, A (Zojirushi Corporation), 22 September, 1992 (22.09.92), Full text; Figs. 1 to 11 (Family: none)	3
Y	JP, 4-174272, A (Hitachi, Ltd.), 22 June, 1992 (22.06.92), Full text; Figs. 1 to 5 (Family: none)	5-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.184058/1984 (Laid-open No.97693/1986) (NIPPON SANSO CORPORATION),	2

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 27 March, 2001 (27.03.01)	Date of mailing of the international search report 03 April, 2001 (03.04.01)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/09388

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	23 June, 1986 (23.06.86), Full text; Figs. 1 to 4 (Family: none)	
Y	JP, 10-205996, A (Sanyo Electric Co., Ltd.), 04 August, 1998 (04.08.98), Full text; Figs. 1 to 10 (Family: none)	5-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.109994/1990 (Laid-open No.68989/1992) (Sharp Corporation), 18 June, 1992 (18.06.92), Full text; Figs. 1 to 7 (Family: none)	5-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.45158/1990 (Laid-open No.3976/1992) (Sekisui Plastics Co., Ltd.), 14 January, 1992 (14.01.92), Full text; Figs. 1 to 3 (Family: none)	8

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